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Modified UPQC Topology using PI and Fuzzy Controller for Power Quality Improvement in Power System

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Abstract: Introduction of more power electronic devices and non-linear loads pollutes the grid and create power quality problems. A unified power quality conditioner (UPQC) is Power electronic based device that mitigates simultaneously the voltage and current concerned Power Quality issues in the power distribution systems. In this paper presents a modified UPQC topology which consists of Series and shunt active filter is connected via common DC-link and a star connected transformer is added in the Shunt Active Power Filter for neutral current suppression and make the balanced system in compensation of three-phase system. In series controller Selective harmonic elimination based Series active filter is used for series compensation. And Id &IQ based control is used for shunt compensation. In the Dc link we add a solar based distribution to make utilize of renewable Energy for compensation and to meet energy Demand. The performance of modified UPQC topology using PI and fuzzy controller has been studied comparatively. Conventional PI controller can be compared with a fuzzy controller for better control, and thus improve the system performance. The effectiveness of the proposed system is verified using the MATLAB simulations.

Keywords: Distribution generation system, UPQC, Power quality issues. PI controller, Fuzzy logic controller, MATLAB.

I. INTRODUCTION

Power quality is very sensitive due to non linear loads, such as rectifier equipment, adjustable speed drives, domestic appliances and arc furnaces. These nonlinear loads draw non-sinusoidal currents from ac mains and cause a type of current and voltage distortion called as 'harmonics'. These harmonics causes various problems in power systems and in consumer products such as equipment overheating, capacitor blowing, motor vibration, transformer over heating excessive neutral currents and low power factor [1-2]. Common Power quality problems are most of commercial, industrial and distributed networks. The most frequent cause of power quality problems are natural phenomena such as lighting, switching phenomena resulting in oscillatory transients in the electrical supply. Hence for all these reasons, from the consumer point of view, power quality issues will become an increasingly important factor to consider in order satisfying good productivity. To address the needs of energy consumers trying to improve productivity through the reduction of power quality related process stoppages and energy suppliers trying to maximize operating profits while keeping customers satisfied with supply quality, innovative technology provides the key to cost-effective power quality enhancements solutions. However, with the various power quality solutions available, the obvious question for a consumer or utility facing a particular power quality problem is which equipment provides the better solution. Previously the solutions to mitigate are as fixed compensation, resonance with the source impedance, very difficulty in tuning the filter parameters, these are through conventional passive filters which have limitations to ignite the need of active and hybrid filters. This paper presents a PI control and fuzzy logic control based unified power quality conditioner to mitigate all the power quality problems and compares both result. Unified power quality conditioner is the combination of series and shunt active filter [3-4]. Series active filter has the responsibility for compensating the voltage distortion on the source side while shunt active filer is used to compensate load side power quality problems. The control strategy is at the heart of the any compensating device. Many control strategies are reported in the literature to control a power system with various controllers and optimized techniques [5-10]. To determine the reference signal of the current and voltage of the three phase unified power quality conditioner [11]. The most common are instantaneous PQ that is known as IPQ theory and synchronous frame which is known as SRF theory is used for controlling this device [1]. The performance of unified power quality conditioner is mainly depends on how quickly and accurately compensation signals are derived. The control strategies used here are based on PI Controller and fuzzy logic controller [12]. The PI control based techniques are simple and reasonably effective. Further, the control of UPQC based on the conventional PI control is prone to severe dynamic interaction between active and reactive power

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flows [13]. The conventional PI controller may be replaced by a Fuzzy Logic Controller (FLC) for better response [9]. The beauty of fuzzy logic controller over PI controller is that it does not need an accurate mathematical model and can handle nonlinearity, work with imprecise input and may be more robust than the conventional PI controller. Recently fuzzy logic controller has generated a great deal of Interest in various applications and has been introduced in the power systems and power electronics field [5, 6, 9, 12].

II. CONFIGURATION OF UPQC

The three phase source is taken from the 500 kVA grid. The series converter is connect through the series reactor from the line similarly through the shunt reactor is shunt converter.

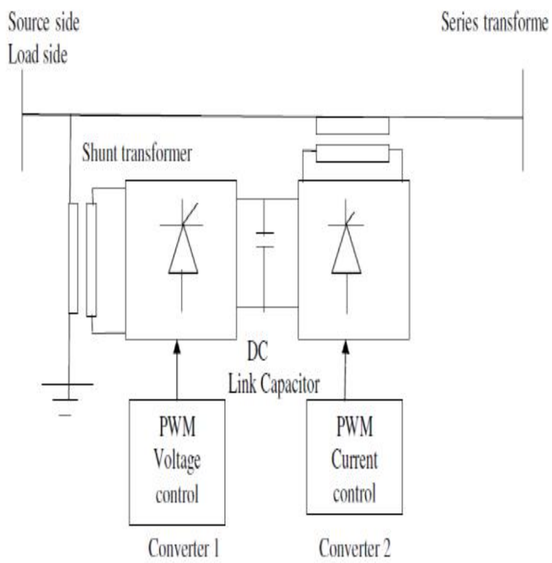

Fig: 1. Basic system configuration of a general UPQC

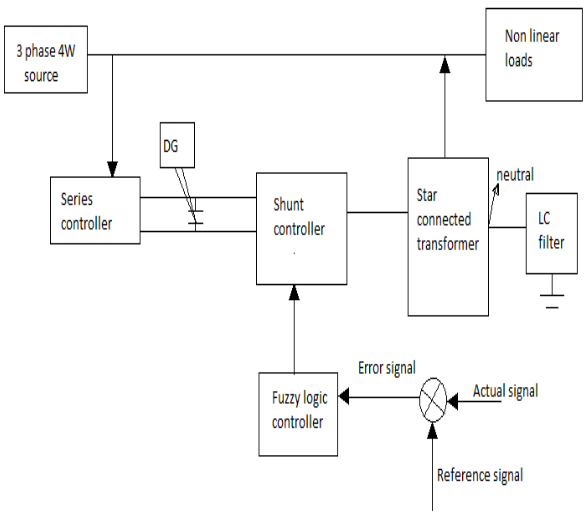

Fig: 2. Proposed UPQC model

The series and shunt converter is linked with common DC link and capacitor. The DG is connected in the DC link of this UPQC. The series active power filter is based on selective harmonic strategy.
The series converter control strategy is based on the selective harmonic distortion. The line current (IL) to compensate the voltage sags/swell for the series converter as in (1).

$$I_L = \frac{2v\sin\delta/2}{X} + \frac{V_c}{X} \qquad (1)$$

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The power flow in the line is used for the series converter modeling and it is expressed as in (2)

$$P = VI_L \cos(\delta/2) \qquad (2)$$

Where
V is the magnitude of voltage
X is the series reactance of the transmission Line

The power balance equation is used for shunt converter modeling and it is expressed as in (3)

$$V_{dc}I_{dc} = \frac{3}{2}(E_{sR}I_{sR}+E_{sI}I_{sI}) \qquad (3)$$

Where
Vdc is the voltage value of DC link
Idc is the current Value of DC link
EsI is the power injected in the shunt converter
EsR is the power injected in the shunt reactance
IsI is the magnitude of shunt current
IsR is the magnitude of shunt reactance current

The common DC link modeling is based on the shunt converter DC side circuit as in (4)

$$\frac{dv_{dc}}{d} = \frac{-1}{c_s}\left(I_{dc}+\frac{V_{dc}}{R_p}\right) \qquad (4)$$

Where
Cs is the capacitor value of DC link
Idc is the current value of DC link
Vdc is the voltage value in the DC link
Rp is the resistance in the circuit

The UPQC is connected with reduced rating star connected transformer at the load side. The neutral of the star connected transformer is connected with LC filter and is given to earth. This hybrid approach reduces the phase current harmonics and compensates the neutral current.

I. Fuzzy Logic Controller
The sensed DC link voltage value is input of the FLC. The voltage value is converted in to fuzzy value by fuzzification method. In this fuzzification method the input values is converted in to linguistic value, which may be viewed as labels of fuzzy sets. In fuzzy control system, the measurement of the input signal is interpreted as a fuzzy singleton. In the shunt active power filter the FLC strategy is implemented for comparing the actual signal with reference signal to give the error signal. Then by using fuzzy rules that error signal is compensated to eliminate the distortions.

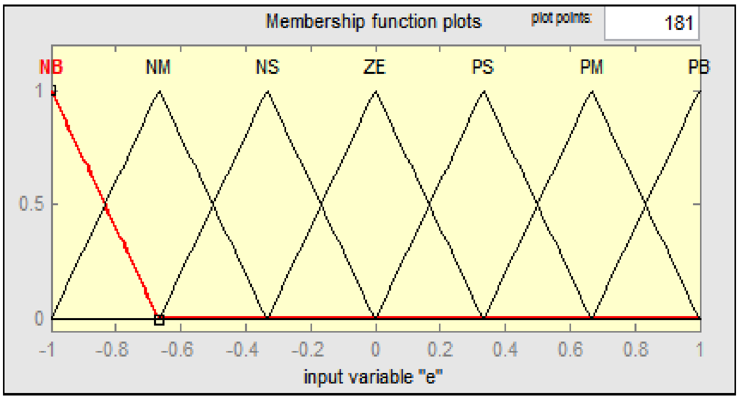

Fig: 3. Fuzzification Input voltage variable 1

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Here mamdani type fuzzification is used. In mamdani type fuzzy inference system, both the input and output linguistic variables will take fuzzy variables as values. The input variable of fuzzification is shown and output variable of defuzzification is shown in following figure .The membership function of a fuzzy set is a generalization of the indicator function in classical sets. Fuzzy variables are defined by membership function and characterized by shapes, position and width or whole overlap. The triangular membership is used in the controller.

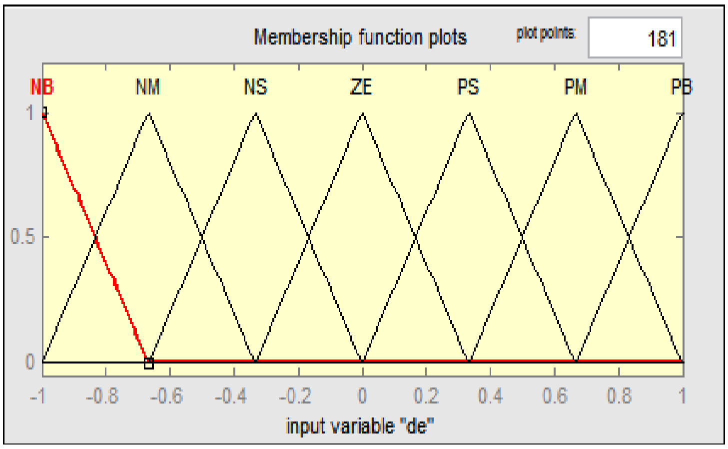

Fig:4. Fuzzification input voltage variable 2

The fuzzy rule base assemblies plant information and apply the human control expertise to the given problem. The Rule base was formed using a 7*7 matrix. Centroid of area method is used for defuzzification method to obtain the crisp value from the fuzzy value.

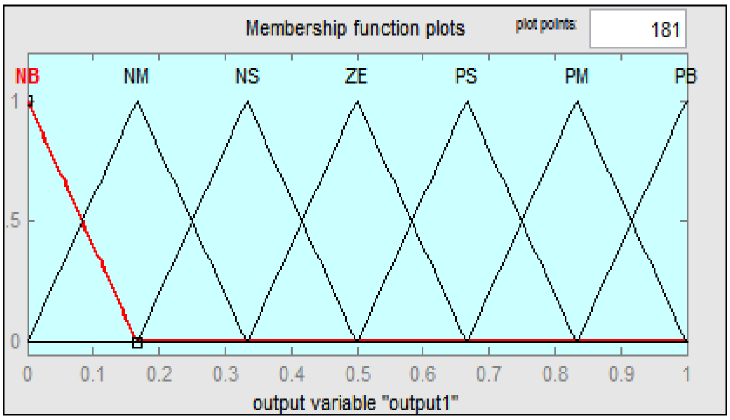

Fig: 5. Defuzzification Output Voltage Variable

II. PI CONTROLLER

In this paper many investigations in the area of UPQC of shunt and series active power filter interconnected system have been reported in the past and a number of control strategies have been proposed to achieve improved performance. The proportional plus integral (PI) control and integral control approach is successful in achieving zero steady start error in the UPQC of the system. Several APF and UPQC application works presented in the literature are about improving the performance of the compensator. But it exhibits relatively poor dynamic performance as evident by large load and sag/swell. Moreover the transient settling time is relatively large. In the application of optimal control technique, the controller design is normally based on fixed parameter model of the system delivered by a linearization process. The nature of the UPQC PI control problem makes it difficult to ensure stability for all operating points when an integral (or) PI Controller is used.

III. PROPOSED MODEL

The proposed model with and without UPQC as shown in Fig 6 and Fig 7. The analysis of model is done by comparing the performance analysis of PI and FLC controllers. In the modified UPQC the star connected transformer is connected

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with LC filter to suppress the neutral current and the LC filter is earthed. In series active power filter the selective harmonic elimination technique is used to mitigate voltage sag/swell in the system. In shunt active power filter the fuzzy and PI based control technique is used mitigate the harmonic distortions which are present in the system.

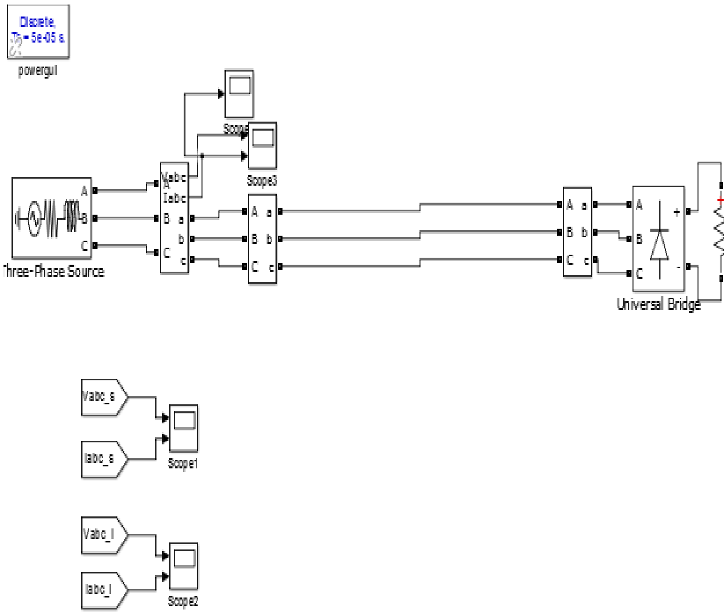

Fig: 6. Without UPQC model

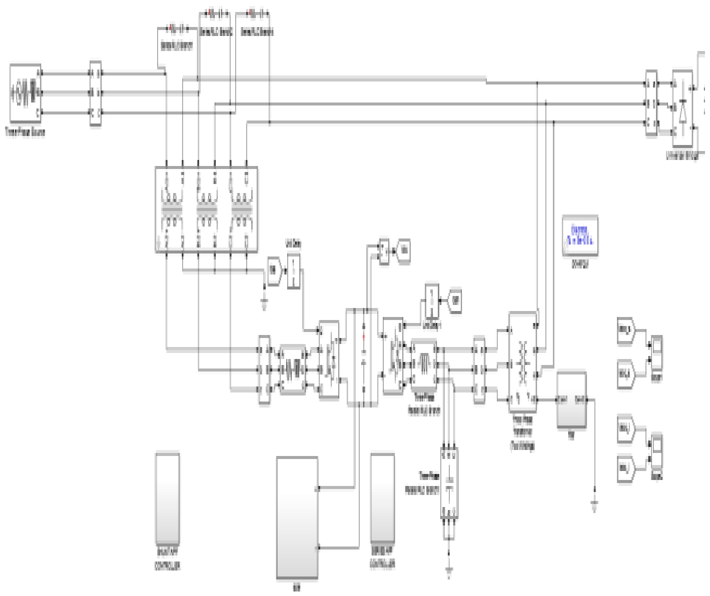

Fig: 7. With UPQC model

IV. SIMULATION RESULT

The UPQC has simulated using the proposed modified UPQC with DG and without DG by FLC and PI controller. The source voltage waveform is distorted before connecting the UPQC and becomes sinusoidal after connecting UPQC. The voltage and current waveform without UPQC is shown in Fig 8 and with UPQC is shown in Fig 10. The total harmonic distortion of source current without UPQC is 30.89% is shown in Fig 9.

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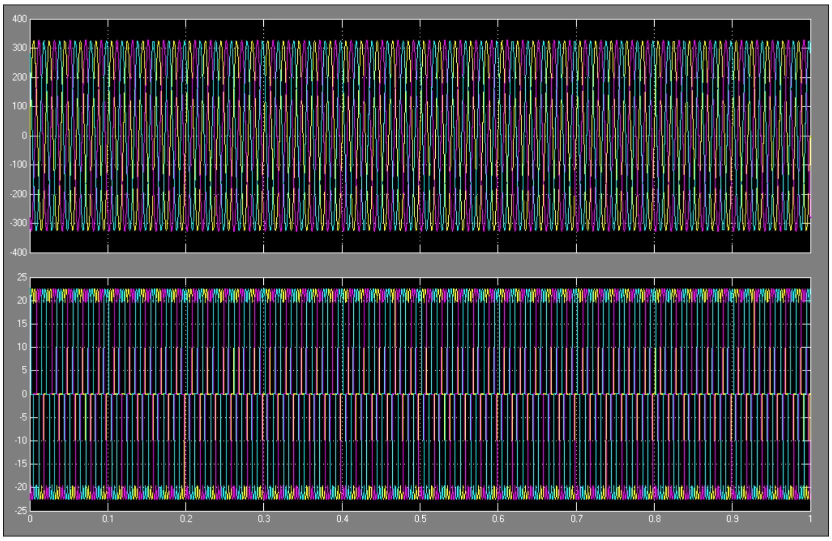

Fig: 8. Voltage and current at source side without UPQC

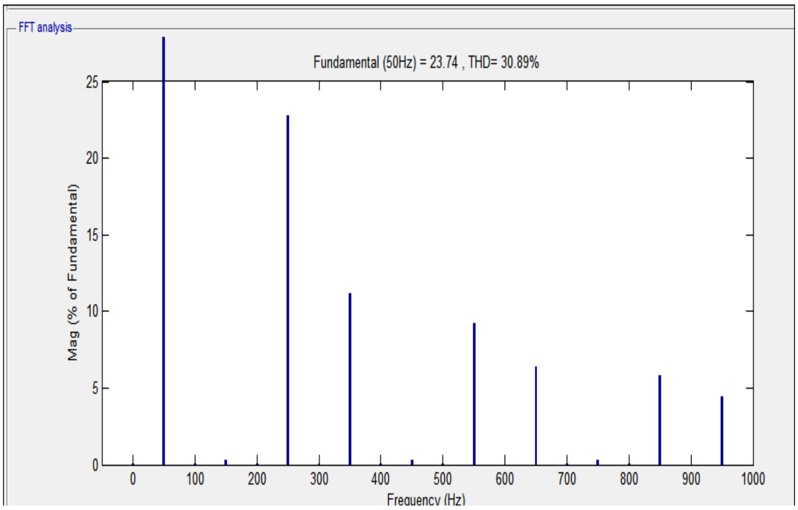

Fig: 9. THD of source current without UPQC

The voltage and current waveform at source side with PI controller based UPQC is shown in Fig 10. The THD of source current with PI controller based UPQC is 1.82% is shown in Fig 11.

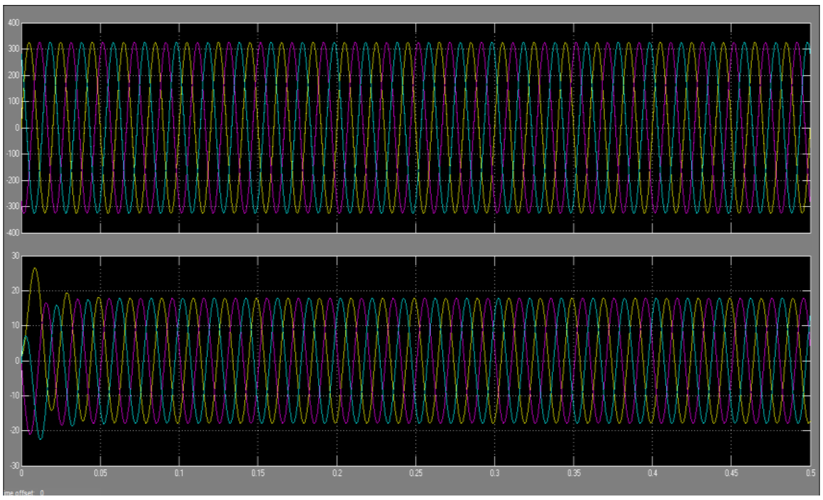

Fig: 10. Voltage and current at source side with PI controller based UPQC

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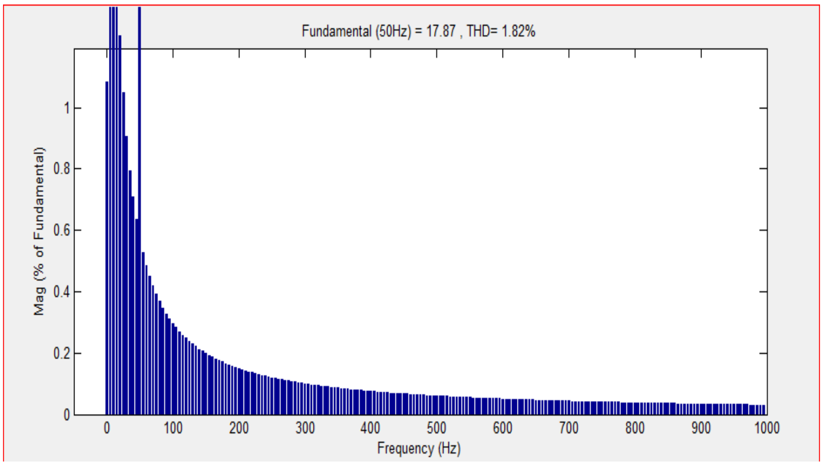

Fig : 11. THD of source current in with PI controller based UPQC

The voltage and current at source side with fuzzy controller based UPQC is shown in Fig 12. The THD of source current in with FLC is 1.46% is shown in Fig 13.

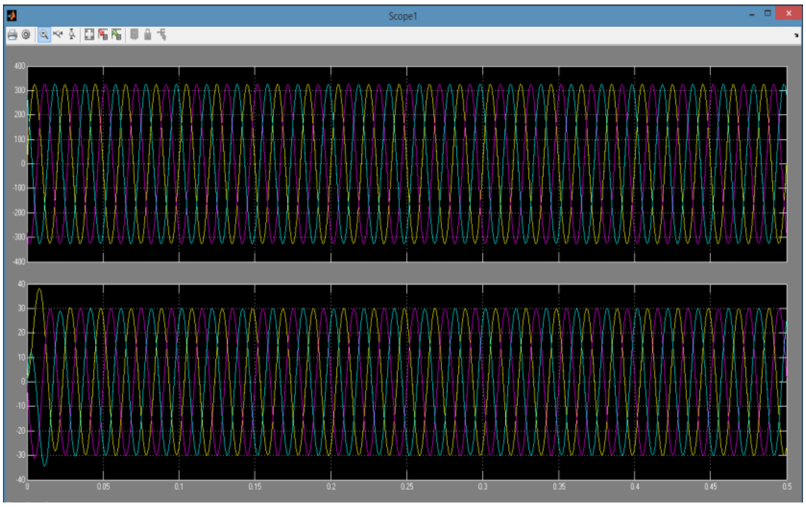

Fig: 12. Voltage and current at source side with fuzzy controller based UPQC

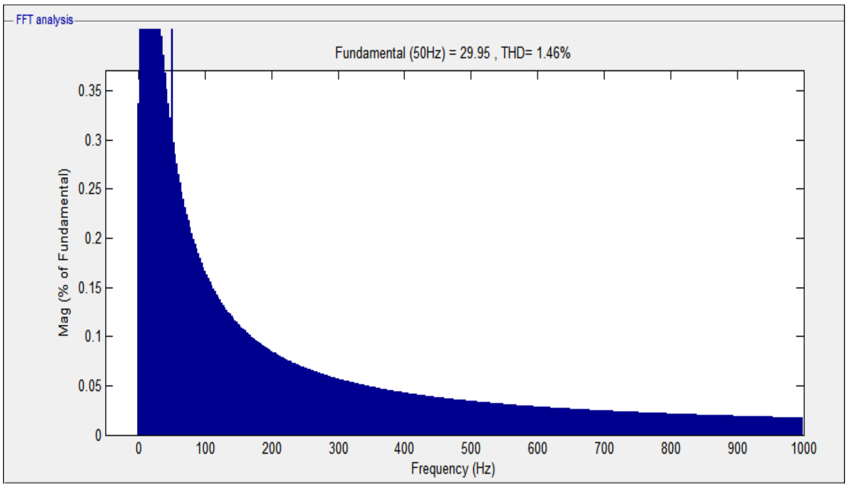

Fig: 13. THD of source current in with fuzzy controller based UPQC

The voltage and current at source side with PI controller based UPQC with DG (solar) is shown in Fig 14. The THD of source current in with PI controller based UPQC with DG (solar) is 4.30% is shown in Fig 15.

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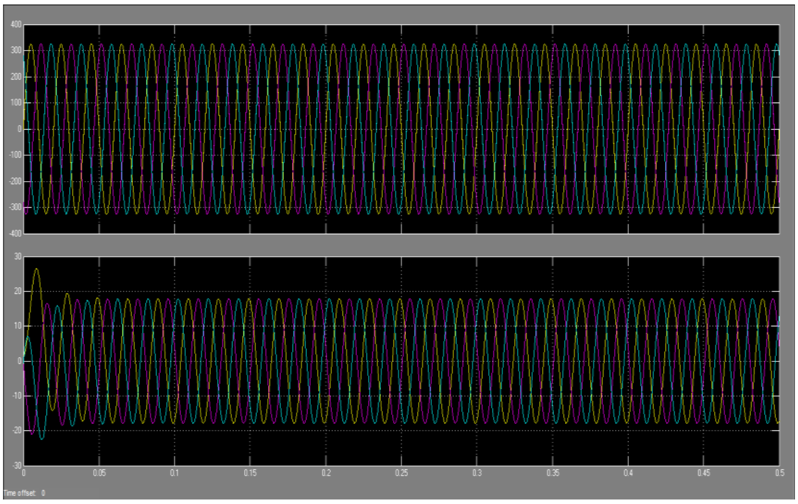

Fig: 14. Voltage and current at source side with pi controller based UPQC with DG(solar)

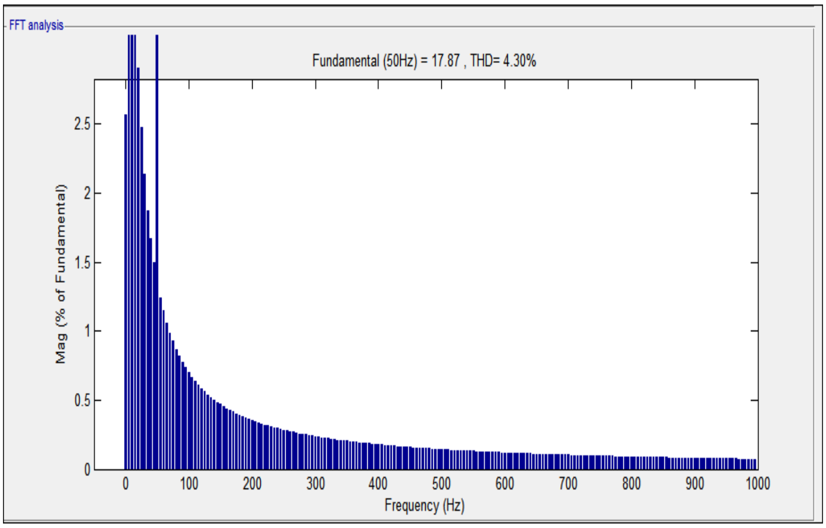

Fig: 15. THD of source current in with PI controller based UPQC with DG (solar)

The THD of source current in with fuzzy controller based UPQC with DG (solar) is 0.40% is shown in Fig 16. The comparative analysis between PI and FLC gives better performance and power quality improvement for fuzzy logic controller.

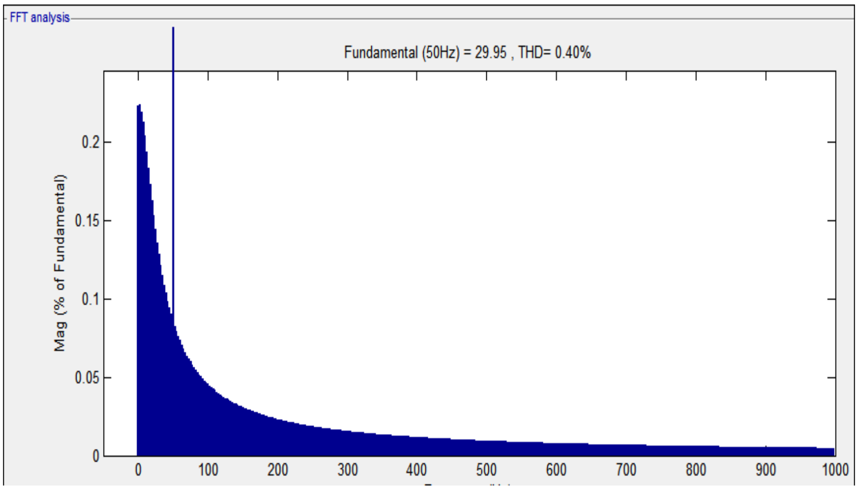

Fig: 16. THD of source current in with fuzzy controller based UPQC with DG (solar)

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V. CONCLUSION

This paper presents modified UPQC with fuzzy logic controller by achieving better power quality strategy. The Distribution system with nonlinear load is constructed and checked for harmonic distortion, then by modeling a modified UPQC with FLC and PI controller for reducing harmonic distortion occurring in the system. By adding a solar based DG in the DC link and its performance also compared with FLC and PI based system. From the above performance studies it is observed that the proposed controller scheme completely mitigates the source current harmonics, load current harmonics, voltage sag/swell and neutral current. Based on the simulation results we conclude that fuzzy based system will give good results than conventional PI controller.

VI. FUTURE WORK

In this we are using a fuzzy and PI based control for Dc link Voltage instead of fuzzy try with some neural network based control it may improve its performance

Instead of single layer control go for multilayer or multilevel control which improves the system performance.

REFERENCES

[1]. V. Khadkikar, A. Chandra, "A New Control Philosophy for a Unified Power Quality Conditioner (UPQC) to Coordinate Load-Reactive Power Demand Between Shunt and Series Inverters, "IEEE Trans. on Power Delivery, vo1.23, no.4, pp. 2522-2534,

[2]. Saaki, Indranil, GT Chandra Sekhar, U. Salma, and B. Shankar Prasad. "Multiconverter unified power quality conditioning system using Artificial Neural Network technique." In India Conference (INDICON), 2011 Annual IEEE, pp. 1-7. IEEE, 2011.

[3]. L. F. C. Monteiro, M. Aredes, and L. A. M. Neto, "A control strategy for unified power quality conditioner," in Proc. IEEE Int. Symp. Ind. Electron., Jun. 2003, vol. I, pp. 391-396.

[4]. H. Fujita, and H. Akagi, "The unified power quality conditioner: The integration of series and shunt active filters, " IEEE Trans. Power Electron., vol. 13, no. 2, pp. 315-322, Mar. 1998.

[5]. Sahu, Rabindra Kumar, Sidhartha Panda, and GT Chandra Sekhar. "A novel hybrid PSO-PS optimized fuzzy PI controller for AGC in multi area interconnected power systems." International Journal of Electrical Power & Energy Systems 64 (2015): 880-893.

[6]. Chandra Sekhar, G. T., Rabindra Kumar Sahu, and Siddhartha Panda. "Load frequency control with fuzzy-PID controller under restructured environment."Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2014 International Conference on. IEEE, 2014.

[7]. Gorripotu, TulasichandraSekhar, Rabindra Kumar Sahu, and Sidhartha Panda. "Comparative performance analysis of classical controllers in LFC using FA technique." Electrical, Electronics, Signals, Communication and Optimization (EESCO), 2015 International Conference on. IEEE, 2015.

[8]. Sekhar, GT Chandra, et al. "Load frequency control of power system under deregulated environment using optimal firefly algorithm." International Journal of Electrical Power & Energy Systems 74 (2016): 195-211.

[9]. Chandra Sekhar, G. T., Rabindra Kumar Sahu, and Siddhartha Panda. "Load frequency control with fuzzy-PID controller under restructured environment."Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2014 International Conference on. IEEE, 2014.

[10]. Sahu, Rabindra Kumar, TulasichandraSekharGorripotu, and Sidhartha Panda. "A hybrid DE–PS algorithm for load frequency control under deregulated power system with UPFC and RFB." Ain Shams Engineering Journal (2015).

[11]. H. Fujita and H. Akagi, ―The unified power quality conditioner: The Integration of series- and shunt active filters, IEEE Trans. Power Electronics, vol. 13, no. 2,pp. 3 15-322, 1998

[12]. Singh B. N., Chandra A., Al-Haddad K. and Singh B., "Fuzzy control algorithm for universal active filter," IEEE Conf. Proc. Power Quality, pp. 73-80, 1998.

[13]. P. Ramya and J. Bhavani, " Different Controllers of UPQC for Power Quality Evolution "International Journal of Current Engineering and Technology ,Vol.3, No.5 (December 2013), pp 1733-1738

[14]. B. Singh. K. Al-Haddad. and A. Chandra. "A review of active filters for power quality improvement." IEEE Trans. Ind. Electron. vo1. 46.no. 5..0ct. 1999, pp.960-971.

[15]. Sahu, Rabindra Kumar, Sidhartha Panda, and GT Chandra Sekhar. "A novel hybrid PSO-PS optimized fuzzy PI controller for AGC in multi area interconnected power systems." International Journal of Electrical Power & Energy Systems 64 (2015): 880-893.

[16]. Chandra Sekhar, G. T., Rabindra Kumar Sahu, and Siddhartha Panda. "Load frequency control with fuzzy-PID controller under restructured environment."Control, Instrumentation, Communication and Computational Technologies (ICCICCT), 2014 International Conference on. IEEE, 2014.

[17]. Gorripotu, TulasichandraSekhar, Rabindra Kumar Sahu, and Sidhartha Panda. "Comparative performance analysis of classical controllers in LFC using FA technique." Electrical, Electronics, Signals, Communication and Optimization (EESCO), 2015 International Conference on. IEEE, 2015.